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New Computer System Simplifies Programming of Mathematical Equations

The problem:

To devise a low-cost desk-top computer system that will permit a scientist or engineer with no prior programming knowledge to solve problems in higher mathematics the way he now handles arithmetic problems on a desk-top calculator. The system should also provide the experienced programmer with the flexibility he needs to solve nonroutine problems.

The solution:

An automatic-programming, on-line, multiterminal computer system, called AMTRAN (Automatic Mathematical Translator), which permits a scientist or engineer to enter mathematical equations in their natural mathematical format as they would appear in a textbook and to obtain an immediate graphical display of the solution on an oscilloscope.

How it's done:

The system consists of an operator keyboard, a storage and control keyboard, an oscilloscope, and an electric typewriter. Entry is made in two principal ways: through the keyboards, which provide several hundred of the more common functions and operations of mathematical analysis and through the typewriter, which uses mnemonic labels to provide several thousand less common functions and operations. The system provides the user with graphical and alphanumeric results as rapidly as the computer can obtain them. A rapid evaluation of intermediate results is afforded by the oscilloscope, with an attached Polaroid camera to provide a permanent record of the final results.

As the equations are entered from the keyboard, the typewriter types out the equations in proper mathematical format. At the end of each mathematical statement, a *carriage return* button is depressed which

informs the computer that the mathematical statement has been completed and which causes a carriage return on the typewriter. When the *carriage return* button is depressed, a parenthesis count is made to ensure that parentheses have been properly closed. If such is not the case, the typewriter types out an abbreviated error message. If the user is unfamiliar with the system and wants to know what the abbreviated error message means, he may push an *instructions* button, whereupon the typewriter types out the full error message. In this way, the experienced user does not have to wait for the type-out of the complete error message, while the beginner can call for it if he needs it. The *instructions* button also serves two other functions. At the beginning of operations, pressing the *instructions* button and then any other button provides a type-out giving the purpose of the other button and the rules for using it. The computer system also rejects improper mathematical expressions.

The user may operate in either a "desk calculator" mode or in a "stored program" mode. In the former, the computer executes operations as the user presses the buttons. At the same time, the computer temporarily stores the list of button pushes made by the user. At the end of a mathematical statement, the user may transfer the entire statement to any one of a large number of unassigned blank buttons on the keyboard, making it part of the "stored program" mode. Thus, the user has the option of permanently retaining a pushbutton list of mathematical operations and transforming it into a portion of a stored program. The advantage of the desk calculator mode of operation is that the user can check the work at each step. For operations such as multiple integrations, which require an appreciable time to execute, the operator may elect to operate in the "stored program" mode.

(continued overleaf)

In this instance, a lighted *execute* button is pushed, causing the light to go out and suppressing execution. Then a list of button pushes (and mnemonic code type-ins) is entered without executing the associated operations. When the *carriage return* button is depressed at the end of the mathematical statement, the pushbutton list is terminated. The pushbutton list can then be assigned to a blank pushbutton or mnemonic call code as previously described, after which execution is restored. Complete programs are developed by embedding equations or sets of equations into a single pushbutton list. An entire program which may run for hours is then set into motion when a single button is pushed.

The AMTRAN system operates at three levels. First, it contains a real-time FORTRAN IV interpreter which permits the user to type in, execute, and debug FORTRAN programs on line. The user, if he wishes, may then automatically punch a FORTRAN source deck and process it in the conventional manner. The second level provides tightly programmed operators for numerical analysis, and the third

level provides a large number of "convenience" operators for classical analysis. The highest level at which the AMTRAN system may operate depends on the computer with which it is used.

Notes:

1. The AMTRAN system lends itself exceedingly well to multistation, time-sharing operation.
2. The system described was developed for use with the IBM 1620 and Univac 1107 computers, but is adaptable to other computer systems as well.
3. Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Marshall Space Flight Center
Huntsville, Alabama 35812
Reference: B66-10361

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: Robert N. Seitz
Juris Reinfelds, and Lawrence H. Wood
(M-FS-441)